

**IN THE CLAIMS:**

1. In an existing optical network comprising a multiplicity of destination terminals and a like multiplicity of pairs of optical fibers extending one pair each between one of said destination terminals and an intermediate terminal, each of said pair including a first fiber and a second fiber, selected ones of said destination terminals including an OIU (optical interface unit), each OIU having an input optical connector and an output optical connector and each OIU for extracting data on lightwaves received at said input optical connector and injecting data onto lightwaves transmitted from said output optical connector, each of said OIUs connected by said input and output optical connector to each fiber of a corresponding one of said multiplicity of pairs of optical fibers, and said intermediate terminal connected to a primary terminal by at least a primary pair of optical fibers, apparatus for providing optical data transmission comprising:

a first conversion circuit located in said intermediate terminal having an input optical connector and an output optical connector said first conversion circuit for converting optical data to electrical data and electrical data to optical data, said first conversion circuitry further including electrical connections;

a transmission loop comprising a plurality of said selected destination terminals and a like plurality of corresponding pairs of optical fibers connecting said plurality of destination terminals to said intermediate terminal, said first fiber of each of said plurality of pairs terminating with a first optical connector at said intermediate terminal, and said second fibers of each of said plurality of pairs terminating with a second optical connector at said intermediate terminal;

at each one of said selected destination terminals, said first fiber connected to said output optical connector of said OIU (optical interface unit), and said second fiber connected to said input optical connector of said OIU; and

5 at said intermediate terminal each said first optical connector of each one of said first fibers of said plurality of pairs connected to said second optical connector of said second fiber of another one of said plurality of pairs, except said first optical connector on a first fiber of a first pair is connected to said input connector of said conversion circuit and said second optical connector on a second fiber of a last pair is connected to said output connector of said conversion circuit; and

10 a second conversion circuit located in said intermediate terminal for converting optical data to electrical data and electrical data to optical data and electrically connected to said electrical connections of said first conversion circuitry, said second conversion circuitry also optically connected to said primary pair of optical fibers extending between said intermediate terminal and said primary terminal.

2. The apparatus of claim 1 and further comprising at least two first conversion circuits and a corresponding number of transmission loops and wherein  
20 the electrical connectors of each of said at least two conversion circuits are connected to said second conversion circuitry.

3. The apparatus of claim 2, wherein said at least two of said first conversion circuits comprises four first conversion circuits, and are connected to a corresponding four transmission loops.

4. In an existing optical network comprising a multiplicity of destination terminals and a like multiplicity of pairs of optical fibers, each pair having a first fiber and a second fiber, and each one of said destination terminals connected to an intermediate terminal by one of said multiplicity of pairs of optical fibers, and said  
 5 intermediate terminal connected to a primary terminal by at least a pair of primary optical fibers, apparatus for providing upgraded optical data transmission comprising:

a first conversion circuit located in said intermediate terminal having an output optical connector and an input optical connector for connecting said optical fibers to optically transmit and receive bidirectional data between said  
 10 intermediate terminal and selected ones of said multiplicity of destination terminals, said first conversion circuit for converting optical data to electrical data and electrical data to optical data, said first optical conversion circuit further including electrical connections;

a first and last OIU (optical interface unit) located in a first and last destination terminal, respectively, each of said first and last OIUs, including  
 15 an input optical connector and an output optical connector, said OIUs for extracting and inserting data on lightwaves traveling over a pair of said multiplicity of pairs of said optical fibers, and said lightwaves being received at said input connector and transmitted from said output connector of said  
 20 OIUs;

a first pair of said multiplicity of pairs of optical fibers extending between said intermediate terminal and said first destination terminal and having said first fiber of said first pair connected to said output optical connector of said conversion circuit;

a last pair of said multiplicity of pairs of optical fibers extending  
 between said intermediate terminal and a last distribution terminal and having  
 said second fiber of said last pair connected to said input optical connector of  
 said conversion circuit, the second fiber of said first pair and the first fiber of  
 5 said last pair connected so as to form a series optical loop extending between  
 said output optical connector of said conversion circuit and at least through  
 said first and last distribution terminals and back to said input optical  
 connector of said conversion circuit; and

second conversion circuitry located in said intermediate terminal for  
 10 converting optical data to electrical data and electrical data to optical data, and  
 electrically connected to said first conversion circuitry, said second  
 conversion circuitry also optically connected to said pair of optical fibers  
 extending between said intermediate terminal and said primary terminal.

5. The apparatus of claim 4 wherein said second fiber of said first pair  
 15 and said first fiber of said last pair are connected directly to each other.

6. The apparatus of claim 4 and further comprising at least another pair  
 of optical fibers extending between at least another destination terminal and said  
 intermediate terminal, said another pair of optical fibers being connected such that  
 said series optical loop extends from said output optical connector, through said first,  
 20 said another, and said last destination terminals and then to said second optical  
 connector.

7. The apparatus of claim 6 wherein said at least another destination  
 terminal comprises a second and third destination terminal, and said at least another  
 pair of optical fibers comprises a second and third pair of optical fibers, each pair  
 25 having a first fiber and a second fiber extending between said intermediate terminal

and said second and third destination terminals, respectively, said second fiber of said second pair being connected to said first fiber of said third pair, and said first fiber of said second pair connected to the second fiber of said first pair, and said second fiber of said third pair coupled to the first fiber of said last pair such that said series optical  
5 loop extends from said output optical connector of said first conversion circuit at said intermediate terminal through said first, second, third and last destination terminals and then back to said input optical connector of said first conversion circuit.

8. The apparatus of claim 4 and further comprising a plurality of said first conversion circuits located in said intermediate terminal and wherein said multiplicity  
10 of destination terminals and said multiplicity of pairs of optical fibers are divided into substantially a like plurality of groups forming a plurality of series optical loops, such that each one of said plurality of series optical loops are associated with one of said plurality of first conversion circuits.

9. The apparatus of claim 6 and further comprising a plurality of said first  
15 conversion circuits located in said intermediate terminal and wherein said multiplicity of destination terminals and said multiplicity of pairs of optical fibers are divided into substantially a like plurality of groups forming a plurality of series optical loops such that each one of said plurality of series optical loops forming a plurality of series optical loops are associated with one of said plurality of first conversion circuits.

20 10. The apparatus of claim 4 wherein said optical interface unit is a broadband optical interface unit.

11. The apparatus of claim 6 wherein said optical interface unit is a broadband optical interface unit.

12. The apparatus of claim 7 wherein said optical interface unit is a  
25 broadband optical interface unit.

13. In an existing optical network comprising a multiplicity of destination terminals and a like multiplicity of pairs of optical fibers extending one pair each between one of said destination terminals and an intermediate terminal, each of said pair including a first fiber and a second fiber, selected ones of said destination  
5 terminals, including an OIU (optical interface unit) and each OIU having an input optical connector and an output optical connector, and each OIU for extracting data on lightwaves received at said input optical connector and injecting data onto lightwaves transmitted from said output optical connector, each of said OIUs connected by said input and output optical connector to each fiber of a corresponding  
10 one of said multiplicity of pairs of optical fibers, and said intermediate terminal connected to a primary terminal by a first pair of primary optical fibers, apparatus for providing optical data transmission comprising:

a first optical device located in said intermediate terminal and having at least one input optical connector and an output optical connection;

15 a second optical device located in said intermediate terminal having an input optical connector and at least one output optical connector;

a transmission loop comprising a plurality of said selected destination terminals and a like plurality of corresponding pairs of optical fibers connecting said plurality of destination terminals to said intermediate  
20 terminal, said first fiber of each of said plurality of pairs terminating with a first optical connector at said intermediate terminal, and said second fiber of each of said plurality of pairs terminating with a second optical connector at said intermediate terminal,

25 at each of said selected destination terminals, said first fiber connected to said output optical connector of said OIU (optical

interface unit) and said second fiber connected to said input optical connector of said OIU, and

5 at said intermediate terminal each said first optical connectors of each one of said first fibers of said plurality of pairs connected to said second optical connector of a second fiber of another one of said plurality of pairs, except said first optical connector of a first fiber of a first pair is connected to said at least one input connector of said first optical device and said second optical connector of a second fiber of a last pair is connected to said at least one output connector of said second optical device; and

10 said output optical connector of said first device connected to a first fiber of said primary pair of optical fibers extending between said intermediate terminal and said primary terminal, and said input connector of said second optical device connected to a second fiber of said primary pair.

15 14. The apparatus of claim 13 wherein said first optical device is an optical combining device or coupler having a plurality of inputs and said second optical device is an optical dividing device or splitter having a plurality of outputs, and further including a plurality of said transmission loops connected between said plurality of inputs of said optical combining device and between said plurality of

20 outputs of said optical splitting device.

15 15. The apparatus of claim 14 wherein said primary terminal includes an optical splitting device having an input connected to said first fiber of said pair connecting said intermediate terminal and said primary terminal and a like plurality of outputs connected to a like plurality of optical receivers, and an optical combining device having an output connected to said second fiber of said pair extending between

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said intermediate terminal and said primary terminal and a like plurality of inputs connected to a like plurality of optical transmitters.

16. The apparatus of claim 15 and further comprising a first WDM (wave division multiplexer) located in said intermediate terminal optically connected  
5 between the plurality of said second fibers of said last pair of each of said plurality of transmission loops and said plurality of outputs of said optical splitting device, and a second WDM optically located in said primary terminal and optically connected between said plurality of outputs of said optical splitting device and said like plurality of optical receivers.

10 17. The apparatus of claim 13 wherein said first optical device is an optical combining device which includes a second output optical connections and said second optical device is an optical splitting device which includes a second input optical connections, and further including at least a second pair of optical fibers extending between said intermediate terminal and said primary terminal and wherein  
15 said second output optical connector of said combining device is connected to a first fiber of said second pair of optical fibers extending between said intermediate terminal and said primary terminal and said second input optical connector of said optical splitting device is connected to a second fiber of said second pair of fibers extending between said intermediate terminal and said primary terminal.

20 18. The apparatus of claim 14 and further including a plurality of optical bypass switches, one each located at said OIU in said destination terminals and connected across corresponding pairs of said optical fibers at said destination terminals so as to connect said input of said optical interface unit to said output of said optical interface unit in the event of a failure of said OIU in said destination  
25 terminal.



19. The apparatus of claim 15 wherein said optical combining device includes a second output optical connectors and said optical splitting device includes a second input optical connectors, and further including at least a second pair of optical fibers extending between said intermediate terminal and said primary terminal and wherein said second output optical connector of said combining device is further connected to a first fiber of said second pair of optical fibers extending between said intermediate terminal and said primary terminal and said second input optical connector of said optical splitting device is connected to a second fiber of said second pair of fibers extending between said intermediate terminal and said primary terminal.

20. The apparatus of claim 19 and further including a first route protection switch connected between each of said first fibers of said first and second primary pairs and the input of said optical splitting device in said primary terminal and a second route protection switch connected between each of said second fibers of said first and second primary pairs and the output of said optical combining device in said primary terminal, said first route protector switch being actuated in the event of failure of said first fiber of said first primary pair and said second route protector switch being actuated in the event of failure of said second fiber of said primary pair.

21. The apparatus of claim 13 wherein said optical interface unit is a broadband optical interface unit.

22. The apparatus of claim 14 wherein said optical interface unit is a broadband optical interface unit.

23. The apparatus of claim 17 wherein said optical interface unit is a broadband optical interface unit.

24. The apparatus of claim 20 wherein said optical interface unit is a broadband optical interface unit.

25. In an existing optical network comprising a multiplicity of destination terminals and a like multiplicity of pairs of optical fibers extending one pair each between one of said destination terminals and an intermediate terminal, each of said pair including a first fiber and a second fiber, selected ones of said destination  
5 terminals, including an OIU (optical interface unit) and each OIU having an input optical connector and an output optical connector, and each OIU for extracting data on lightwaves received at said input optical connector and injecting data onto lightwaves transmitted from said output optical connector, each of said OIUs connected by said input and output optical connector to each fiber of a corresponding  
10 one of said multiplicity of pairs of optical fibers, and said intermediate terminal connected to a primary terminal by at least one primary optical fiber, apparatus for providing optical data transmission comprising:

at least one optical coupler/splitter having a destination terminal side and a primary terminal side, said destination terminal side having at least two  
15 optical connectors, and said primary terminal side having at least one optical connector;

a transmission loop comprising a plurality of said selected destination terminals and a like plurality of corresponding pairs of optical fibers connecting said plurality of destination terminals to said intermediate  
20 terminal, said first fiber of each of said plurality of pairs terminating with a first optical connector at said intermediate terminal, and said second fiber of each of said plurality of pairs terminating with a second optical connector at said intermediate terminal,

at each of said selected destination terminals, said first fiber  
25 connected to said output optical connector of said OIU (optical

interface unit) and said second fiber connected to said input optical connector of said OIU, and

at said intermediate terminal each said first optical connectors of each one of said first fibers of said plurality of pairs connected to said second optical connector of a second fiber of another one of said plurality of pairs, except said first optical connector of a first fiber of a first pair is connected to one of said at least two connectors on said destination terminal side of said at least one optical coupler/splitter and said second optical connector of a second fiber of a last pair is connected to another one of said at least two connectors on said destination terminal side of said at least one optical coupler/splitter; and

said optical connector on said primary terminal side of said at least one optical coupler/splitter connected to said at least one primary optical fiber extending between said intermediate terminal and said primary terminal.

26. The apparatus of claim 25 wherein said at least one optical coupler/splitter comprises a plurality of optical coupler/splitters, and said at least one optical fiber comprises a first like plurality of optical fibers, and further including a like plurality of said transmission loops connected one each between said at last two optical connectors on said destination terminal side of said plurality of optical coupler/splitters.

27. The apparatus of claim 26 wherein said at least one optical fiber comprises a like plurality of optical fibers and said primary terminal includes a like plurality of optical coupler/splitters, each including an intermediate terminal side with at least one optical connector and a primary terminal side with two optical connectors, said at least one optical connector on said intermediate terminal side of each of said

plurality of optical coupler/splitters connected one each to one of said like plurality of optical fibers, and one of said two optical connectors on said primary terminal side of said plurality connected one each to a like plurality of optical receivers, and the other one of said two optical connectors on said primary terminal side connected one each  
 5 to a like plurality of optical transmitters.

28. The apparatus of claim 26 and further including a plurality of optical bypass switches, one each located at each OIU in said destination terminals and connected across corresponding pairs of said optical fibers at said destination terminals so as to connect said input of said OIU to said output of said OIU in the  
 10 event of a failure of said OIU.

29. The apparatus of claim 27 and further comprising a second like plurality of optical fibers and a like plurality of route protection switches having an intermediate terminal side with two connectors and a primary side with one connector, each of said two connectors on said intermediate terminal side of said  
 15 route protection switch connected to one fiber of each of said first and second like pluralities of optical fibers and said one connector on said primary side of said like plurality of route protection switches connected one each to said at least one optical connector of said like plurality of optical coupler/splitters, said route protection switches being activated in the event of failure of a fiber of said first plurality of  
 20 fibers to disconnect said failed fiber and connect said fiber of said second plurality.

30. The apparatus of claim 25 wherein said optical interface unit is a broadband optical interface unit.

31. The apparatus of claim 26 wherein said optical interface unit is a broadband optical interface unit.

32. The apparatus of claim 27 wherein said optical interface unit is a broadband optical interface unit.

33. The apparatus of claim 28 wherein said optical interface unit is a broadband optical interface unit.

34. The apparatus of claim 29 wherein said optical interface unit is a broadband optical interface unit.

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